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TECHNICAL REPORT

72-54-FL

EFFECT OF COOKING AND FAT LEVEL ON THE OXYGEN UPTAKE OF FREEZE-DRIED COOKED GROUND BEEF

by

R. L. Helmer

and

J. M. Tuomy

December 1971

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory

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FOREWORD

Oxygen has been recognized to have an adverse effect on the quality of freeze-dried foods. It has been found in previous studies that the freeze-dried combination foods such as used in the Food Packet, Long Range Patrol vary widely for their affinity to oxygen. At least one product can be stored in atmosphere for six months at 100°F. and still be edible while most of the others become inedible in a few weeks under the same conditions.

There was some evidence that the cooking of the beef component in combination foods affected oxygen uptake. Therefore, this study was conducted to further isolate the effect of cooking.

The work was performed under project 1J662713AD34, Military Food Service and Subsistence Technology.

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ABSTRACT

Ground beef with fat levels of 10, 15, 20 and 25 percent which was cooked in water to 180°F and cooked with boiling for 20 minutes was freeze-dried and stored at 100°F. Products were withdrawn at 2, 4, 8 and 12 weeks and the head space gas analyzed.

It was found that the more severe cooking resulted in higher oxygen uptakes statistically significant at the 1 percent level. The higher fat levels caused significantly higher uptakes, but they were a small part of the total variance observed.

INTRODUCTION

The adverse effect of oxygen on freeze-dried foods is well known and dictates that these products be packaged and maintained in low oxygen atmospheres. This is expensive and sometimes rather difficult to do through processing and handling in the field. However, investigations concerned with oxygen uptake of freeze-dried foods have shown that they vary widely in their susceptibility to oxygen uptake (Tuomy et al, 1970). Reasons for this are not well understood, but the differences are substantial enough so that while one freeze-dried combination item, such as beef with rice, will still be quite edible after 6 months storage at 100°F canned atmosphere, another, such as spaghetti with meat sauce, will be practically inedible after 4-6 weeks under the same conditions. Both of these products contain ground beef. In a further study attempting to determine the effect of ingredients on oxygen uptake (Tuomy and Fitzmaurice, 1971) it was found that ingredients determined the uptake and that the meat component plays the biggest part. As an offshoot of this study, indications were found that the method of cooking the beef had a bearing on the oxygen uptake of four of the combination meat items studied.

Fat content in the raw meat specified for freeze-dried products used by the Armed Services is held to less than 25 percent due to rehydration problems encountered with higher levels. Although oxidation of freeze-dried meats does not take place with the fat in the way that it does with fresh meats, the level of fat may have some effect on the oxygen uptake of freeze-dried meats.

Zipser and Watts (1961) stated that antioxidants are produced in meat by prolonged cooking above 100°C. However, these investigators did not attempt to identify the compounds formed nor was the meat freeze-dried.

Ground beef is used in four of the eight freeze-dried main components of the Food Packet, Long Range Patrol. In addition, diced beef is used in a fifth item. Furthermore, additional items containing beef are under consideration for other rations and for compressed bars. If it can be shown that the method of cooking the beef has a significant effect on the oxygen susceptibility of the final product, the products can be designed or redesigned to take advantage of this. Therefore, this study was designed to obtain more information as to the effects of the beef cooking on oxygen uptake over a period of storage. Fat level was included in the design.

EXPERIMENTAL METHODS

U. S. choice boneless top rounds were used in the study. The beef was trimmed and the trimmed fat used to make up the fat to the desired levels. The lean and fat were ground through a 1-inch plate separately, analyzed for fat, and then made up to obtain roughly 10, 15, 20 and 25 percent fat on the basis of the analyses. Actual fats obtained after the products were freeze-dried are shown in Table 1. After the fat and lean were mixed, the products were ground through a 3/8 inch plate.

Cooking was accomplished in a steam jacketed kettle in much the same way it would be done if combination products were being made. Half of the products at each fat level were mixed with an equal weight of cold water and heated to 180°F. The meat and water mixtures were then spread thinly on dehydrator trays and frozen in a blast freezer for freeze-drying. The other half of the products were mixed with equal weights of cold water, heated to a boil, and boiled for 20 minutes. The meat and water mixtures were also spread thinly on dehydrator trays and frozen. The frozen products were freeze-dried with a platen temperature of 125°F (radiant heat) and a dehydrator pressure of 100-300 microns to a moisture of approximately 1 percent. The dried products were canned at atmospheric pressure, 125 grams to a No. $2\frac{1}{2}$ can and stored at 100°F. Withdrawals were at 2, 3, 8 and 12 weeks.

Headspace gas analysis was performed by chromatographic means in accordance with the procedure outlined by Bishov and Henick (1966). Sample size was 250 to 500 µl. Experience indicates an anticipated error for the method of approximately $\pm$ 0.25 percent. Cans were equilibrated to ambient temperature overnight before the analyses were run.

Total headspace volume in the cans was determined by compressing 125 gms of product in a laboratory press at 5000 pounds per square inch for 10 seconds and subtracting this volume from the volume of the can. This method is not completely accurate, but since the volume of headspace is very large in comparison with the absolute volumes of the products any error is considered to be of little consequence.

RESULTS AND DISCUSSION

Headspace gas analysis for the various products are shown in Table 2. Analysis of variance with percent of variance on the oxygen uptake is shown in Table 3. All of the factors and two factor interactions are shown to be statistically significant at the 1 percent level. However, percent of variance indicates that storage time, method of cooking, and their interaction comprise most of the observed variance with the method of cooking x fat content interaction comprising 2.6 percent of the variance.

The time in storage comprises a large part of the variance, (54.2 percent) which is to be expected. The method of cooking has a large effect (28.6 percent) on the oxygen uptake with the more severe cooking resulting in the largest oxygen uptake. The interaction of these two variables made up 13.0 percent of the observed variance with the direction of the largest uptake in the direction of greater storage time and the most severe cook. These results are in line with the results of Tuomy and Fitzmaurice (1971).

While the fat content was statistically significant it made up only 0.4 percent of the variance and is not particularly important. When the means are tested by Duncan's multiple range test, the lowest fat is shown to produce the smallest oxygen content and to be the only mean significantly different from the other three at the five percent level.

Analysis of variance for CO_2 production is shown in Table 4. The production of CO_2 follows the oxygen uptake results quite closely except that the storage time x fat content interaction was not significant. In addition, Duncan's multiple range test shows that all of the fat means are significantly different.

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Table 1. Fat percentages as determined analytically in the four levels.

Fat as calculated % (new product)	Fat as determined % (freeze-dried product)
10	33.6
15	38.2
20	49.1
25	55.7

Table 2. Headspace gas analyses in percent of gas composition

Cooking Method	Fat Content %	Time - Weeks 2 O_2	2 CO_2	4 O_2	4 CO_2	8 O_2	8 CO_2	12 O_2	12 CO_2
Cooked to 180	10	17.5	0.2	15.8	0.3	13.1	0.3	10.0	0.4
		17.5	0.2	15.9	0.3	13.1	0.3	10.0	0.4
		17.4	0.2	16.1	0.3	13.2	0.3	10.0	0.4
	15	17.9	0.3	16.2	0.5	13.9	0.4	11.2	0.5
		17.8	0.2	16.4	0.3	13.8	0.4	11.0	0.4
		17.8	0.2	16.3	0.4	13.6	0.4	10.9	0.4
	20	18.0	0.3	16.5	0.3	14.3	0.4	12.0	0.5
		17.9	0.3	16.5	0.3	14.8	0.4	11.4	0.5
		17.9	0.3	16.7	0.3	14.4	0.4	12.0	0.5
	25	20.8	0.3	20.9	0.0	14.3	0.6	12.4	0.6
		17.8	0.3	20.0	0.2	14.6	0.5	12.4	0.6
		17.8	0.3	16.7	0.4	14.5	0.5	12.5	0.6
Boiled for 20 min.	10	14.6	0.3	12.6	0.4	8.3	0.5	3.9	0.6
		15.0	0.3	12.7	0.3	7.9	0.3	3.7	0.6
		14.7	0.3	12.5	0.3	8.7	0.5	3.8	0.6
	15	13.2	0.4	10.0	0.5	5.4	0.6	1.5	0.8
		13.1	0.4	9.7	0.6	5.5	0.6	1.3	0.8
		13.7	0.4	10.6	0.5	5.9	0.6	1.2	0.8
	20	12.8	0.5	9.2	0.7	2.2	0.9	1.3	1.0
		13.7	0.6	8.8	0.6	2.9	0.9	1.2	0.9
		12.7	0.5	9.5	0.8	1.6	0.8	1.2	0.9
	25	12.9	0.5	9.8	0.7	1.3	1.0	1.3	1.0
		12.5	0.6	8.7	0.7	1.3	0.9	1.2	1.0
		13.0	0.5	10.1	0.7	1.3	1.0	1.2	1.0

Table 3. Analysis of variance results showing significance of the factors and the percent of variance attributable to them for O_2 uptake.

Factor	Degrees of Freedom	Significance	Percent of Variance
A (storage time)	4	xx	54.2
B (cooking method)	1	xx	28.6
C (fat content)	3	xx	0.4
AB	4	xx	13.0
AC	12	xx	0.4
BC	3	xx	2.6
Remainder	92	-	0.8

xx Significant at the 1 percent level.

Table 4. Analysis of variance results showing significance of the factor and percent of variance attributable to them for CO_2 production.

Factor	Degrees of Freedom	Significance	Percent of Variance
A (storage time)	4	xx	26.3
B (cooking method)	1	xx	40.8
C (fat content)	3	xx	13.0
AB	4	x	3.7
AC	12	n.s.	
BC	3	xx	7.5
Remainder	9	-	8.7

n.s. not significant
x significant at the 5 percent level
xx significant at the 1 percent level.

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13. ABSTRACT

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